Intensifying the Intensives with the VLBA

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Abstract The U.S. Naval Observatory has, since late 2011, been observing a UT1−UTC Intensive series using the Very Long Baseline Array (VLBA). The primary baseline for these sessions is Mauna Kea – Pie Town (MkPt), using Los Alamos – St. Croix (LaSc) as secondary stations. The session observation times are offset by eight to 16 hours from the IVS Intensives. The VLBA Intensives series are observed at the standard S/X bands. In addition to the daily single baseline VLBA Intensives, VLBA fortnightly sessions using up to four VLBA antennas are observed to characterize the additional baselines. The stations that participate in the fortnightlies are Mauna Kea (Mk), Pie Town (Pt), Los Alamos (La), and St. Croix (Sc). During the period when Sc was offline due to Hurricane Maria damage, a tertiary Intensive was observed using Hancock – Owens Valley (HnOv). Hn and Ov were added to the fortnightlies. We present results of these UT1−UTC series to date and discuss future observing. One issue with the current observations is that the S-band can often be affected by RFI, which usually leads to dropped channels and increased noise in the data. To address the RFI in S-band, test observations are being done to characterize the performance of the VLBA using its more sensitive C-band. Potential future goals include extending the Intensives using three-station baselines to maximize the east-west array.

Keywords USNO, VLBA, Intensives

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1 Introduction

The U.S. Naval Observatory (USNO) has contributed to the International VLBI Service for Geodesy and Astrometry (IVS) as an official Analysis Center for approximately 18 years. As such, the USNO is committed to maintaining and advancing the fields of Earth Orientation Parameters (EOP), the Celestial Reference Frame (CRF), and the measurements of UT1−UTC. The USNO regularly considers ways to contribute to these areas, specifically the measurement of UT1−UTC. One concept was to explore a UT1−UTC series that would act as a backup to the IVS Intensives. Since late 2011, the USNO has observed an Intensive series with the Very Long Baseline Array (VLBA), the VLBA Intensive series. The USNO entered into a 50% timeshare agreement with the Long Baseline Observatory (LBO) in January 2017. Currently, the VLBA Intensives are run as part of the standard operations under the 50% timeshare.

2 Observations

The Intensives are a UT1−UTC series with a primary VLBA baseline of Mauna Kea – Pie Town (MkPt), which has a distance of 4,796 km. In the event that either station is unable to observe, each has a backup. Sc is the backup for Mk, and La is the backup for Pt, producing the secondary baselines ScPt, MkLa, and ScLa. However, due to Hurricanes Irma and Maria, Sc experienced an outage between September 5, 2017 and March 10, 2018. During this outage, a tertiary Intensive series was observed between Hancock – Owens Valley (HnOv). This tertiary series utilized the longest con-

tinental VLBA baseline at 3,885 km. When Sc came back online after the hurricane, USNO was the first to confirm fringes and ensure that the antenna was functional. The Sc antenna is now at full operational capacity. In addition to the various Intensive series, there is also a fortnightly series. The fortnightly series is observed bi-weekly, i.e. once a fortnight. Observations began in late 2014, with the purpose of characterizing the VLBA baselines used in the Intensive series and monitoring them for stability and quality. Initially, there were four VLBA antennas that participated in the fortnightlies: Mk, Pt, La, and Sc. However, Hn and Ov started to be included in the fortnightly series when they were added as a tertiary baseline, bringing the number of VLBA stations to six.

3 VLBA Intensives Setup

In an effort to be as comparable as possible to the IVS daily Intensive series utilizing the baseline from Koke′e to Wettzell (KkWz), USNO uses the VLBA X-band receiver with a dichroic to the S-band receiver. The frequency overlap between the S-band receivers on the VLBA and the IVS antennas is similar. However, the X-band receivers have slightly different frequency coverages. The VLBA X-band receivers range from 8.0−8.8 GHz, while the IVS X-band receivers range from 8.1−8.9 GHz. The data are recorded using the VLBA polyphase filter bank (PFB) personality, which has a total of 16 32 MHz wide spectral windows. For the Intensive and fortnightly series, ten spectral windows are placed across the X-band, and six spectral windows are used across the S-band in single polarization. Figure 1 displays the frequency spacing of the PFB in both S- and X-band frequencies. Due to the fiber optic connections available on the Mk and Pt antennas, e-transfer of data to the Washington Correlator (WACO) is made after each session. However, for the secondary and tertiary stations, fiber optic connections are not yet available; thus, data is transferred via disk packs that are shipped through the mail. After correlation, the data are analyzed in νSolve.

4 Results

All sessions were analyzed and the results compared to C04. As expected, the weighted root mean square (wrms) difference for MkPt is about a factor of two times higher than the KkWz baseline, as can be seen in Figure 2. The KkWz baseline is just over 12,000 km. The longer the baseline, the better the precision, and thus a lower wrms. The VLBA Intensives often experience the well-known issue of high RFI in the S-band. High RFI can lead to dropped channels and increased noise. For instance, in a given observation two out of the six channels are regularly being dropped. Since the S-band is used to calibrate for the ionosphere, the measurement of what the ionosphere contributes to the group delay will not be as good. Therefore, RFI does affect the ionosphere calibration. It then becomes a question of how to deal with this high RFI. One solution to working around or eliminating the RFI in S-band is to observe in a completely different frequency. The C-band is the most sensitive receiver on the VLBA, with a range of 3.9–7.9 GHz. Currently, test sessions are being observed at C-band, see the paper by Dieck.

5 Summary

The VLBA Intensive series has been operational for seven years. Other VLBA sessions include the fortnightly series in which six stations participate. Comparison of the data from the VLBA Intensives to C04 shows a wrms that is approximately 2x higher than that of the IVS KkWz series. High RFI exists in the S-band with investigation into how to address the issue. One such possibility: a C-band session may eliminate this issue, and current test sessions are being observed. Looking to the future, the VLBA Intensives may be extended to three stations, namely Mk, Pt, and Sc, which maximizes the east-west array. The U.S. Naval Observatory is in the process of making the VLBA Intensives available to the IVS, and discussions are underway with the IVS Coordinating Center. However, there are some factors that need to be addressed, i.e.: What metadata do analysts need? What components need to be adjusted for SCHED vs. SKED? The USNO aims to contribute in providing more estimates of UT1−UTC

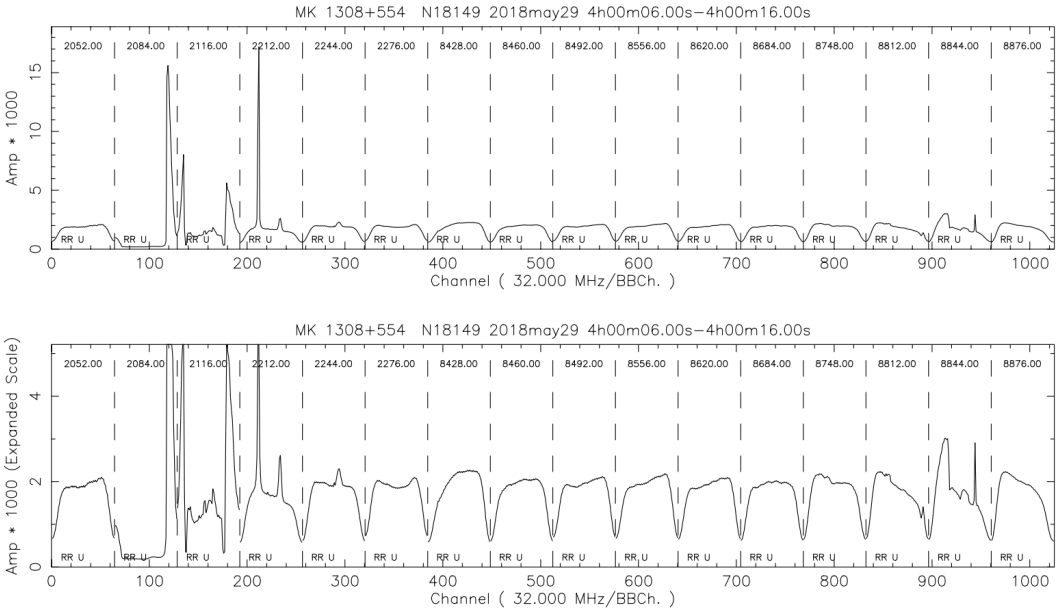

Fig. 1 The first six channels are S-band, and the remaining ten channels are X-band. The frequencies at the top of each panel are in MHz and are the lower edge of the channel. The bottom panel is the zoomed-in amplitude so the RFI in S-band can be seen.

and thus an increased frequency of Intensive observations.

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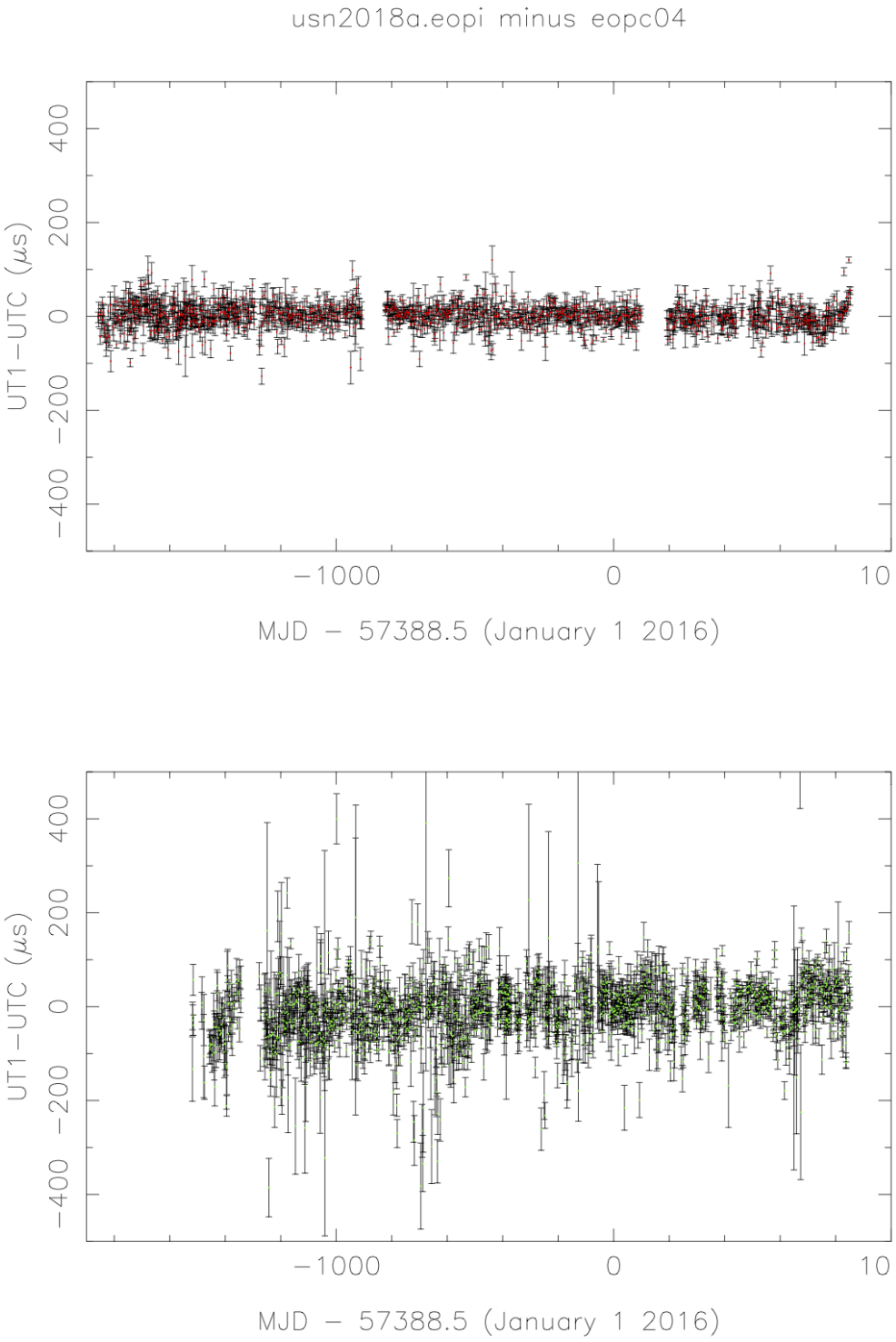

Fig. 2 Results compared to C04. The top plot displays the wrms for the IVS KkWz baseline. In comparison, the bottom plot shows the VLBA MkPt wrms.